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ABSTRACT

Various models of school effects on student achievement were applied in a study of reading and mathematics achievement in the 94 schools of the Oklahoma City Public Schools. The Leadership/Climate Inventory, completed by 1294 teachers, rated school principals in the areas of expectations, instructional leadership, forceful or dynamic style, effective consultation with others, discipline, resources, time management, and evaluation of results. Data were also collected on the allocation and use of instructional time at each school. Achievement data, aggregated to the school level, were based on reading and mathematics scores on the California Achievement Tests. Models have suggested that the following school effects are related to achievement--principals' leadership effectiveness, within-school cohesiveness among teachers, prior achievement in the school and instructional time. Path analysis was used to study these relationships, as well as differences between upper and lower grades. Results supported the principal effects and within-school cohesiveness models, although the effects were stronger in mathematics than in reading. Effects were also stronger in the elementary and fifth year grades than in the middle schools and high schools. Instructional time was also related to achievement, especially in mathematics. (GDC)

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CAUSAL MODELING OF SCHOOL EFFECTS ON ACHIEVEMENT

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March, 1985

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Causal Modeling of School Effects on Achievement

Introduction

Schools are more than mere buildings. They are collections of people who share a great number of experiences over the course of an academic year. The nature of those experiences constitutes a basis for the effectiveness (or lack thereof) of the schooling process. There are many possible ways of thinking of effectiveness; in this report, we employ a relatively limited definition -- one which focuses on standardized achievement scores as an indicator of effectiveness. While this focus necessarily delimits the conclusions to statements about correlates and causes of achievement, such a limitation seems justified in view of the current emphasis on achievement scores.

Why analyze school means on achievement? Even though it is true that those analyses ignore within-school achievement variation, they still address important issues. One of the reasons why those analyses are important is because the variation between-schools is related to individual students' scores variation. Recent analysis from our district estimated the overall correlation (across all grade-levels) between individual student scores and a variable that represents between-school variance on achievement. That regression of individual student performance on among-school achievement showed a (significant) correlation of +.31, indicating that individual student performance and between-school differences are <u>not</u> independent.

One could argue direction of causality (do among-school differences cause among-student differences or vice versa?), but the relation between the two constructs is not arguable. The point of this discussion is that among-school differences are related to differences among students.

Another reason for attending to differences among schools is that the school forms a logical and meaningful cohort. Students, teachers, and other staff identify with "their" school, and (whether appropriately or not), schools are compared with each other. The district also publishes standardized achievement scores by school (e.g., Hall, 1983); this seems further testimony to the notion that variation among schools is not regarded as trivial.

In this research project we have examined several factors. The study began with the idea of having teachers at each site rate their principal on numerous aspects of his or her instructional leadership. Survey items also tapped the general school climate. Since the survey items yielded data that could be aggregated to the school level, it also seemed worthwhile to aggregate student achievement scores to the school level. This procedure permitted relational analyses with the school as the unit of analysis. For analyses in the early grades, the allocation and use of the available instructional time was also examined for its relation to student achievement. Additionally, the obtained degree and the number of years of experience of the principal were analyzed. The research also examined the amount of within-school variation in the teachers'

perceptions of their principal. All of these analyses and methods are described in detail in the full technical report (Crawford and Watson, 1985).

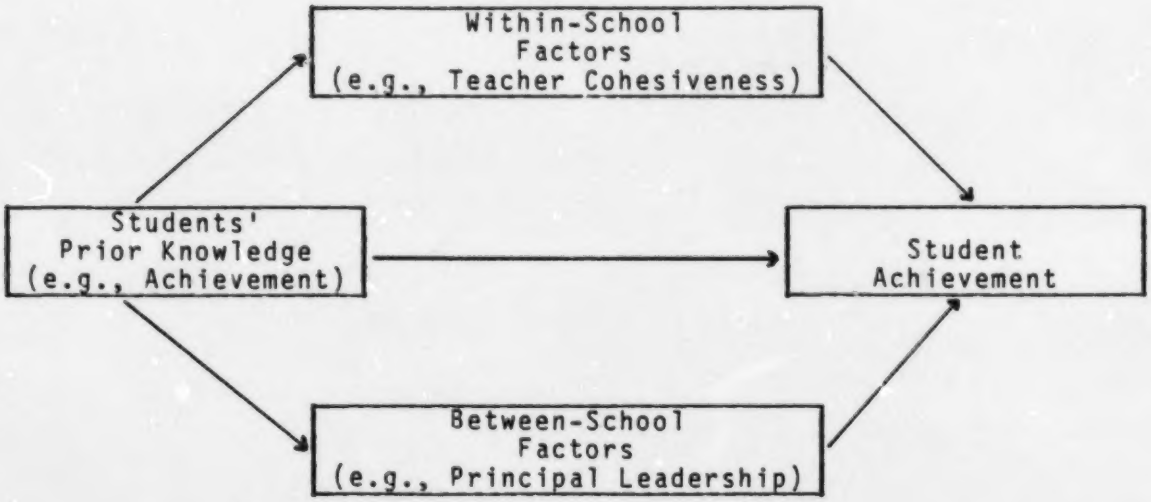
A recent session on "Assessing Effective Schools" at the 1984 American Educational Research Association convention contained five papers (Pink and Wallace, 1984; Schweitzer, 1984; Chase, 1984; Hall and Chase, 1984; Sanders, et al., 1984). However, only one of the five related survey data to observed achievement (Schweitzer, 1984). The remaining papers were reports of projects in which the literature was reviewed, aspects or components of "effective" schooling were extracted and surveys were developed that were based on those components. This study began similarly, but also included correlations with achievement, factor analyses and structural modeling of school effects.

One fairly recent review of school and teacher effects research has synthesized findings from many studies into a structural model of influences on student learning (Centra and Potter, 1980). Their model hypothesizes that school or school district conditions (e.g., between-school variance) have an impact on within-school conditions (such as administrative organization and instructional organization) and on teacher characteristics like qualifications, experience and aptitudes. The authors propose that within-school conditions and teacher characteristics are correlated, though no causal relation was hypothesized. The model also posits that teacher characteristics affect teaching performance (behaviors), which in turn, affects

(and is affected by) student behavior. Within-school conditions are expected to have a direct impact on student behavior, which influences the student learning outcomes.

The one other set of causal agents is represented as "student characteristics", including such indices as social class, aptitudes, and prior learning. The student characteristics factor is presumed to impact directly on teaching performance (behaviors) and on student behavior and on student learning outcomes. The "exogenous" factors in the model are the school or school district conditions and the student characteristics factors; they are presumed to be "given" and are not determinable by factors within the model. All other proposed factors are "endogenous"; that is, there is at least one or more causal agents (within the model) that are hypothesized as impacting on them.

Centra and Potter (1980) correctly point out that no single study has measured and assessed the effects of all their proposed factors. The current OCPS study did not have available resources for measuring teacher and student classroom behavior, for example. This study did, however, assess several important components that were contained within the Centra-Potter model. It seems worthwhile to make explicit the conceptual model that forms the context for the current study.



In this model, prior achievement is the only exogenous variable, with all other factors presumed to be determinable from within the model (i.e., they are endogenous). The relational analyses carried out within the context of this model were with the school as the unit of analysis. Findings presented later in this report will address the efficacy of this conceptualization of school effects. In addition, empirical tests of the influence of total time and instructional time on achievement growth are carried out.

The remainder of this report presents, in order: methods of data collection and analysis, results of analyses, and discussion of implications of results.

Method

Subjects

The Leadership/Climate Inventory was developed in mid-year of the 1983-84 academic year, and copies were sent to all of the

(approximately 2500) teachers in the district in March of 1984. More than half of the teachers responded, yielding 1294 usable protocols. All 94 schools in the district were represented in the data (with an average of 13.8 teacher questionnaires per school). With such a large number of teachers responding (and such a high percentage of the total population), we may be reasonably confident that the population of all OCPS teachers was adequately sampled. Although individual teachers could not be identified, respondees were asked to indicate their school. This permitted aggregation and anaylsis of school-level data. Principals were assured that individual schools would not be identified to administrators or in any research report.

One of the main reasons for administering the survey to teachers was to be able to give feedback to principals on how they were rated by their staff. This feedback occurred in a timely fashion during the Spring semester (and therefore pre-dated this research report). Computer printouts were translated onto a blank questionnaire to show each principal: (1) his or her own mean ratings on each item, and (2) a "comparison mean" representing the average on that item for all schools at the same grade-level as that particular principal. Anecdotal evidence suggested that principals did attend to this feedback. Such feedback could be a valuable source of information to the principal concerning the perceptions of his or her instructional staff.

Instruments

Student achievement scores were aggregated to the school level. Total reading and Total math NCE (Normal Curve Equivalent) California Achievement Test (CAT) scores were used. School-level means represent the between-school measure of achievement in the anaylses with the school as the unit of analysis. Two years of achievement data were analyzed: from end-of-year 1983 and end-of-year 1984. Those occasions are taken as pre-scores and post-scores for the 1983-84 academic year.

The survey of principal leadership and school climate was developed and used during the 1983-84 academic year. Teachers completed the questionnaire in March and April, 1984 and principals were given feedback in May, 1984. The questionnaire consisted of 82 items, grouped (a priori) within the following 8 subsections:

A. High Expectations
B. Instructional Leader
C. Forceful/Dynamic
D. Consulting Others Effectively
E. Creating Order/Discipline
F. Resources
G. Using Time Well
H. Evaluating Results

The paper by Watson, et al. (1985) gives internal consistency reliability statistics (Cronbach's Alpha) for the entire instrument and for the separate subsections. Factor analyses were also per-

formed in order to identify underlying dimensions within the 82 item questionnaire.

Another survey was sent to Elementary and Fifth Year Center principals during the Spring semester (1984). This instrument was a short (10 item) questionnaire concerning the allocation and use of instructional time at each school. This survey was not sent to Middle School and High School sites because the upper grades curriculum does not yield satisfactory estimates of the "typical" students' time use by category. In the early grades it is possible to estimate how much time a typical student will spend in various activities (of an "academic" vs. "non-academic" nature). In the upper grades, with some students moving toward vocational and others toward college preparatory programs, it becomes less reasonable or accurate to talk about the instructional content of a "typical" student's time in school. The analyses of instructional time allocation is based on Elementary and Fifth Year Center sites.

Individual item data and factor scores were correlated with school-level achievement for both the school-level means and for the within-school cohesiveness measures. Formal path analyses were carried out to examine the model of school effects that was briefly presented earlier. Wherever possible, analyses were carried out for all schools (N of 94 or N of 89, not counting special centers) and separately by grade-level. In addition to the analyses of the survey responses of teachers, path analytic models assessed effects of the quantity of schooling.

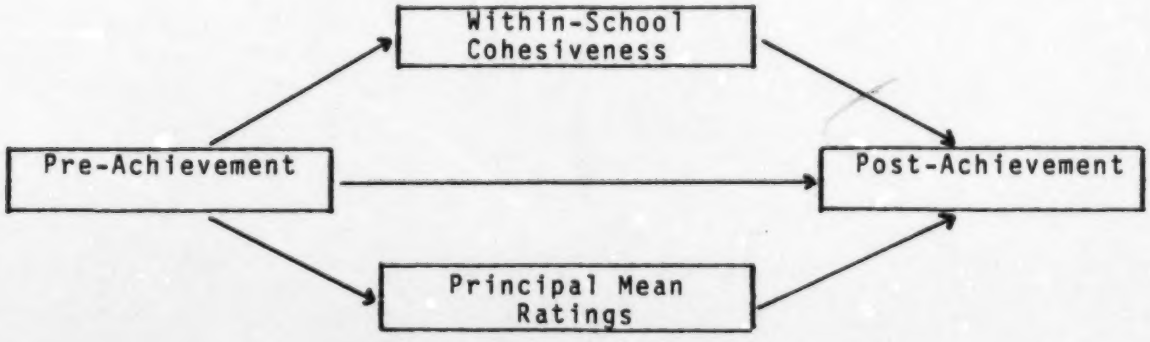
Results: Causal Modeling of Achievement Growth With the School as the Unit of Analysis

It was pointed out in the introduction that the Centra and Potter (1980) model had some influence on our thinking about the nature of school effects on student achievement scores. Also, the work of John Carroll (1963) has a great deal to say about determinants of academic growth. By fitting theoretical causal models to the current data, it may be possible to gain insight into causes and consequences of school-level achievement gains.

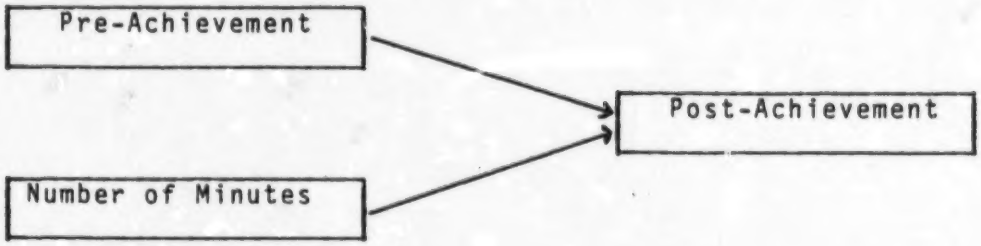
Since least-squares regression procedures are used, the "gains" that are used as indicators of school-level growth are regression-adjusted estimates, and not raw gains. By partialling out the variance due to prior achievement, the relations with the outcome represent effects on residualized achievement.

The tests of the fit of the data to the causal models have two structures as "frameworks" or foci. Analyses are replicated for both reading and math, and when possible, for separate grade-levels as well as for the overall sample. The methods used are standard path analytic procedures, as explained in Pedhuzar (1982).

The teacher survey data (after aggregation to the school-level) were used to test the following model.



The school-level time allocation data were used in tests of the below model.



Path analysis is a method of using structured multiple regression equations to assess theoretical models. In the context of the current study, the results of such analyses have practical implications as well as implications for the understanding of school effects. The practical implications are that we should be able to make recommendations that can be reasonably expected to improve the achievement performance of schools. Given the nature of the models being tested, it is apparent that the recommendations will be concerned with principal leadership, within-school factors, and the allocation of instructional time.

The first causal modeling results are from analyses of the teacher survey data. The two "school effects" factors are represented as within-school cohesiveness among teachers and the mean ratings given the principal at each school. The school-level pre-achievement is also taken as a causal influence on post-achievement. Broadly conceived in this fashion, we have not put specific measures into the model to represent within-school cohesiveness and principal

mean ratings on leadership. Our first inclination was to insert the factor scores from the first factors that resulted from the cohesiveness analyses and the factor analyses of mean ratings. However, a more careful examination of the nature of those two factors convinced us that those two (first) factors were not the best choices (despite the fact that they were certainly the strongest underlying dimensions -- in terms of percentage of variance accounted for). The first factor from the cohesiveness analysis and from the analysis of mean responses were both heavily "affective" in nature. They reflect teacher perceptions of their principal as one who is effective in interpersonal interactions, is friendly, treats teachers with respect, and is respected by teachers. These aspects of principal leadership and school climate are important for establishing and maintaining staff morale, but are not clearly defensible as direct determinants of achievement.

In order to select cohesiveness and mean rating factors that could be justified as causal determinants of achievement, we examined prior theoretical and empirical work regarding causes of achievement growth. Much of the earlier-cited work on principal effectiveness has pointed to the administrative functions of the principal role. Teachers are responsible for instruction, and principals are responsible for facilitating that instruction by supplying teachers with necessary materials and through the selection of qualified staff. Factor 3 in the set of factors from the analysis of principal mean ratings is most closely aligned with these notions -- a

measure of the success of the principal as an administrative manager.

The next step was to select the best candidate among the cohesiveness factors. In order for teacher cohesiveness or likemindedness within a school to have an effect on school-level achievement growth, it was considered necessary to tap teacher attitudes and perceptions that relate to factors that have theoretical and empirical support for their influence on achievement. This suggested a need for measurement of perceptions regarding academic matters, behavior management factors, and also policy regulations (for example, district policy on the use of criterion-referenced management systems). Factor 2 from the cohesiveness analyses most nearly meets these requirements. That factor has items dealing with implementation of district (and state and federal) policy and orientation toward academics and behavior management concerns.

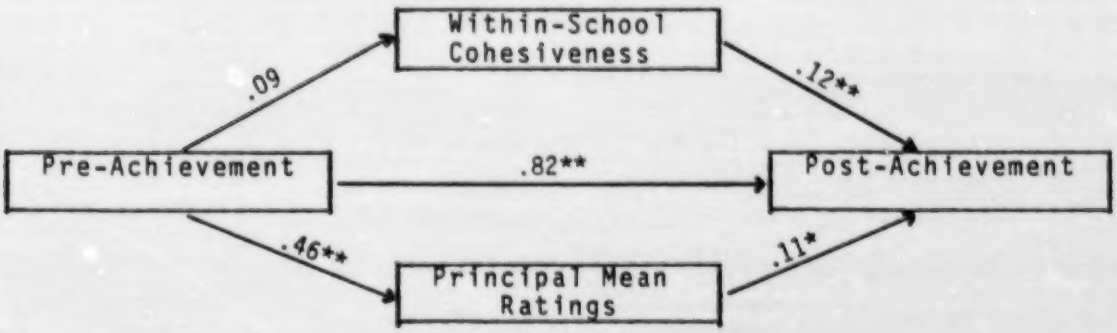
The two selected factors[+] were entered into path analyses along with school-level means on pre and post achievement (end-of-year 1983

[+] For future studies, we are exploring the use of new methods of causal modeling, namely the use of LISREL (Linear Structural Relations). LISREL makes use of maximum likelihood methods that solve some of the problems associated with ordinary least squares regression models. For example, in LISREL there is a distinction between "manifest" and "latent" variables. The latent variables are being tested for theoretical relations, even though they are assumed to be "unobserved". The manifest variables are taken as (observed) measures of the constructs represented by the latent variables. More than one manifest variable can be taken as an indicator of a latent variable. So, in the current work, it would not be necessary to select only one measure of cohesiveness and only one measure of principal ratings.

and 1984) in order to assess growth in the 83-84 academic year. The models were replicated in both reading and math and were calculated for the overall sample of schools (N of 89) and by grade level.

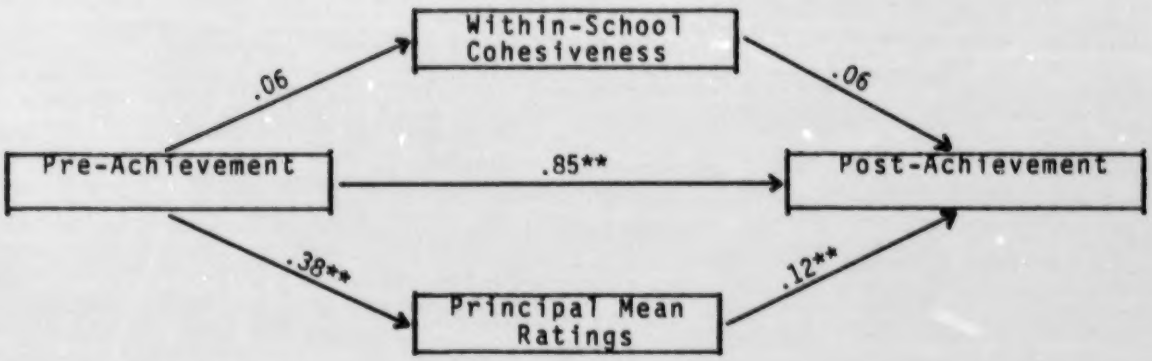
The first results are for the total sample (N of 89).

School Effects in Math



* .05 < P < .10
** P < .05

School Effects in Reading



** P < .05

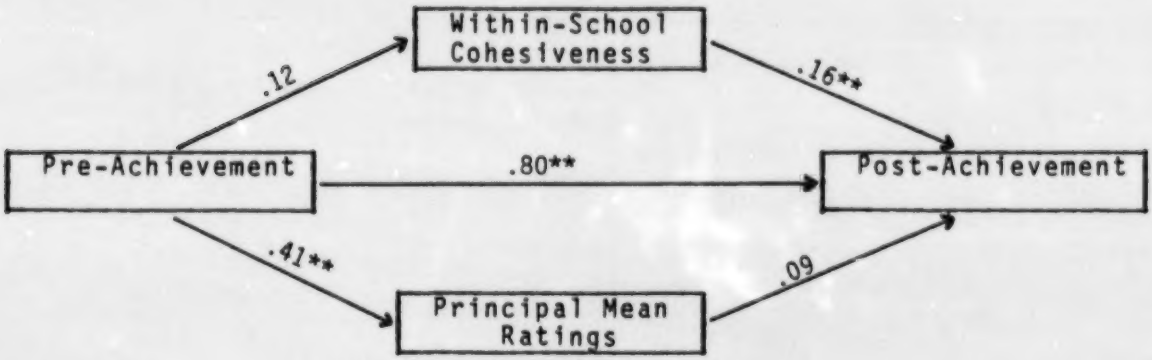
The above results indicate some support for the theorized model, with effects somewhat stronger in math than in reading. In

math, the only hypothesized path that was not significant was the one from pre-achievement to within-school cohesiveness. Even there, the coefficient was positive, indicating a slight trend whereby higher achieving schools (on pre-scores) also have higher within-school cohesiveness. The direct effects of principal leadership and cohesiveness on school-level achievement growth were positive and significant. As expected, the direct effect of pre-scores on post-scores was the strongest effect.

In reading, the within-school cohesiveness factor is not (statistically) significant as a cause or consequence of school-level achievement. The coefficients are positive, as they were in math, but are not significant. The reading analyses are supportive of the part of the model that proposes that pre-achievement has a direct impact on post-achievement and that principal mean ratings on administrative management are affected by the (pre) achievement level of the school and have a direct impact on achievement growth.

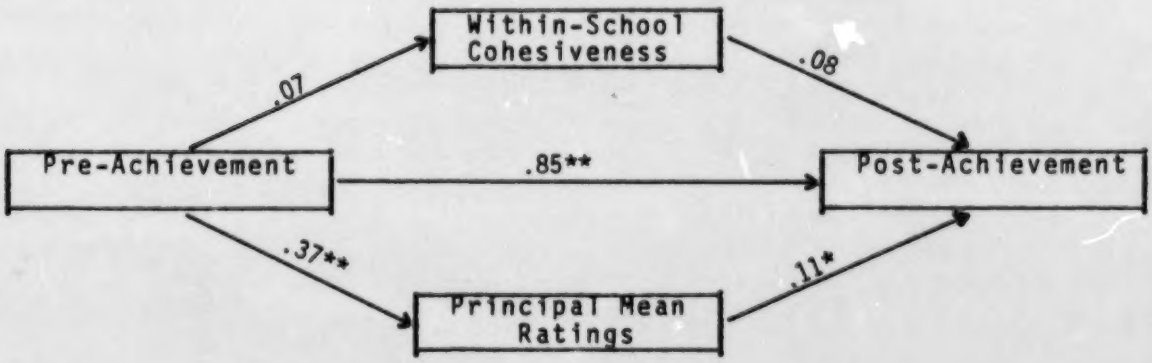
The next models address differences in grade levels by combining elementary schools and fifth year centers in one analysis and middle school and high schools in another analysis. Ideally, these analyses would have analyzed each of the four grade-levels separately, but the Ns per grade-level were too low, so we used a two-level, lower grades vs. upper grades distinction.

School Effects in Math, Elementary Schools and Fifth-Year Centers



** P < .05

School Effects in Reading, Elementary Schools and Fifth Year Centers



* .05 < P < .10
** P < .05

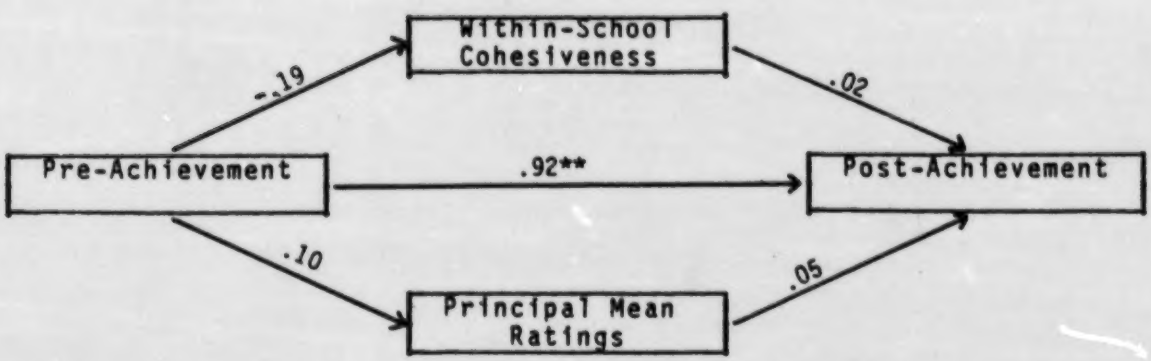
In the lower grades in math, all coefficients were positive, but not all were significant. Within-school cohesiveness among teachers had a (significant) direct impact on achievement growth, but was not affected by pre-achievement. The ratings on principal leadership were

influenced by pre-achievement, but did not significantly impact (adjusted) post-achievement. As in all analyses, the direct effect of pre on post-achievement was the strongest in the model.

In reading, the path coefficients in the early grades were similar in sign and significance to the overall analysis. The within-school cohesiveness factor did not significantly influence growth; nor was it significantly determined by pre-achievement levels. However, the principal's administrative ratings were influenced by pre-achievement in reading, and had a significant impact on achievement gains in reading. The direct impact of pre on post achievement was again significant.

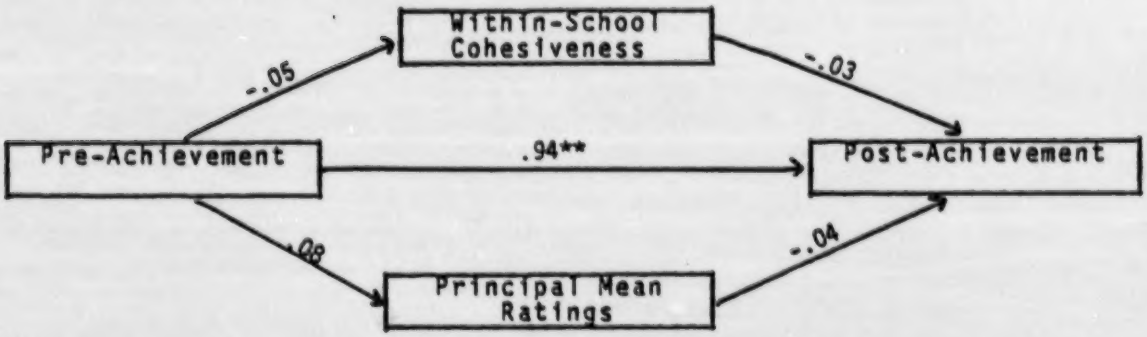
The next models address school effects in middle and high school grades (N of 21 schools).

School Effects in Math, Middle and High Schools



** P < .05

School Effects in Reading, Middle and High Schools



** P < .05

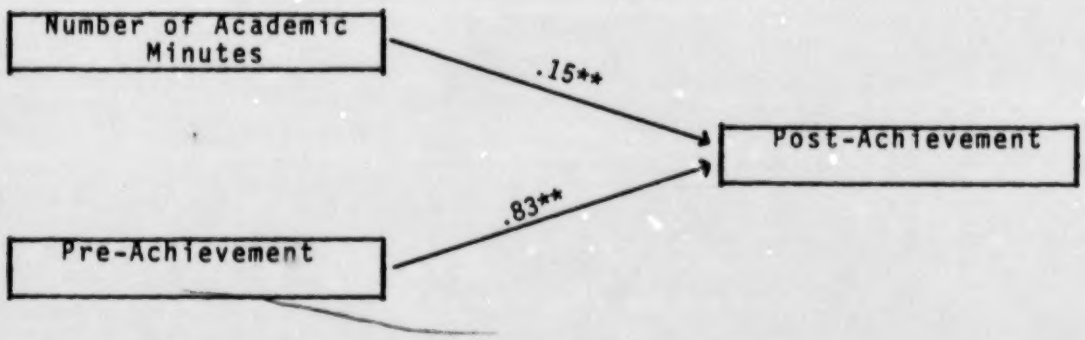
The results for the models at the middle and high school levels are quite different from the results for the lower grades. The conclusion is basically that the models don't fit the data in the upper grades. In fact, the only path that is significant in reading or in math is the direct impact of pre on post-achievement. The magnitude of that path is greater in the upper grades than in the overall analysis or in the early grades. The other hypothesized paths, to and from cohesiveness and to and from principal administrative ratings are very low, and some (4 of 8 across reading and math) are negative in sign.

Admittedly, the statistical power of these N of 21 analyses is low, but even if we ignore statistical significance and attend only to the magnitude and sign of the coefficients, we would still conclude that the data do not consistently or meaningfully fit the

theoretical model in the upper grades. It seems accurate to say that achievement as measured by the CAT is not determined by principal leadership or by within-school cohesiveness among teachers in middle schools or high schools.

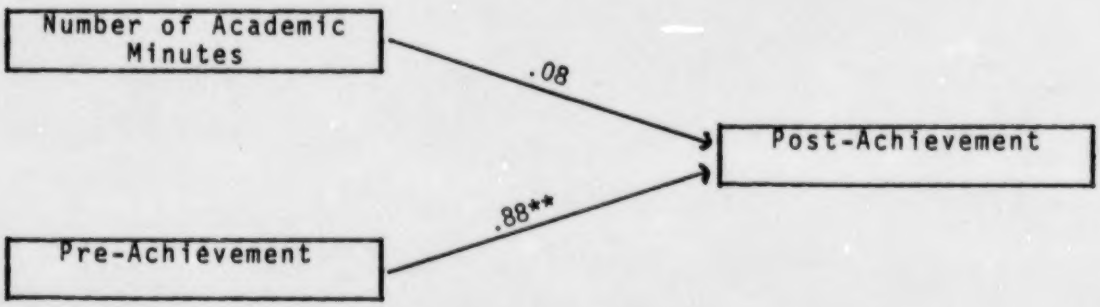
The next results address the impact of allocated time for academic instruction on achievement growth in reading and math. Since the time allocation survey was only sent to elementary schools and fifth year centers, the maximum N was 67 (one school failed to return the survey). Earlier results have shown that point-in-time achievement can be predicted from the number of academic minutes; the following models assess the impact of time on achievement growth (i.e., post-achievement as adjusted for pre-achievement). The overall results are presented first (elementary schools and fifth year centers combined), followed by results for elementary-only and fifth year-only.

Effects of Time Allocation
on Math, Overall



** P < .05

Effects of Time Allocation
on Reading, Overall

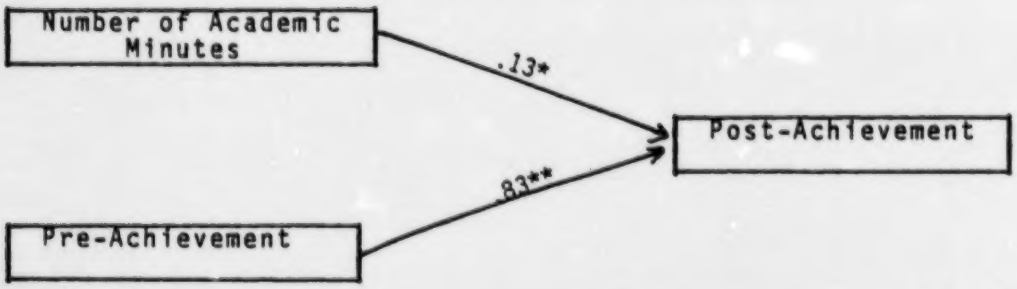


** P < .05

The results of the overall (N of 67) analyses in math showed significant effects of pre-scores and of the number of academic minutes on achievement. That is, the schools with daily schedules that allocate more time for academic instruction are the ones that show the greatest growth in school-level math achievement. In reading, the coefficient for the path from allocated academic time to adjusted achievement was not statistically significant, though it was positive in sign. The probability of observing a coefficient of this size on this sample, by chance, was between .10 and .25. We can say there was only a trend in reading for more allocated time to relate to greater achievement growth, since the effect was not statistically significant. Both the reading and math analyses showed significant paths from pre to post achievement.

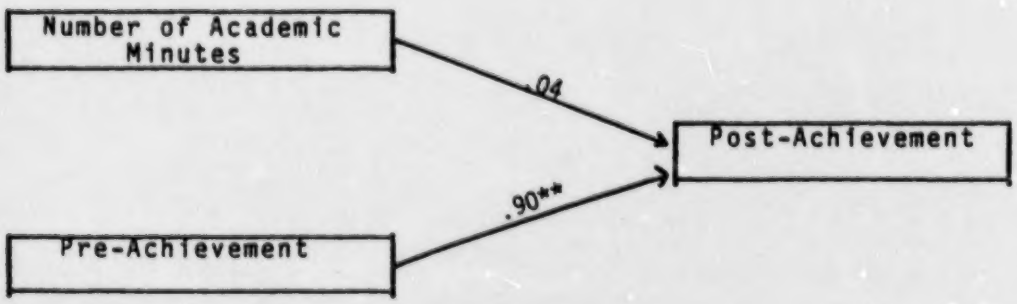
The next analyses assess the time allocation model separately in elementary schools (N of 54) and in fifth year centers (N of 13).

Effects of Time Allocation on
Math, Elementary Schools



* .05 < P < .10
** P < .05

Effects of Time Allocation on
Reading, Elementary Schools

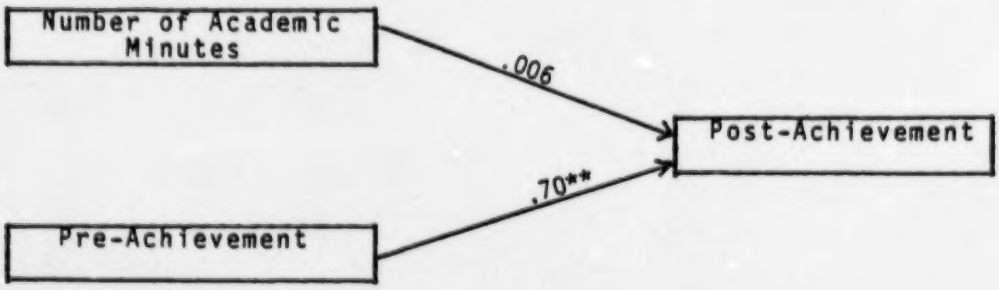


** P < .05

The elementary school results show the same pattern as the overall analyses of time allocation effects. The impact of academic time on achievement growth is significant in math, but not in reading. In the reading analyses, the effect is positive, but only slight (F-ratio for the path coefficient was < 1.0). In both reading and math, pre-achievement has a very strong impact on post-achievement scores.

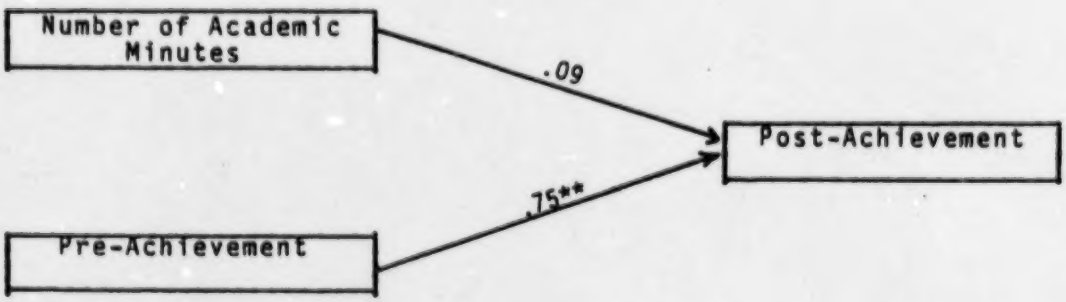
The last results are from analysis of the time allocation model in fifth year centers (with N of 13).

Effects of Time Allocation on Math, Fifth Year Centers



** P < .05

Effects of Time Allocation on Reading, Fifth Year Centers



** P < .05

The results for fifth year analyses do not indicate significant impact of allocated academic minutes on adjusted achievement. Even without consideration of statistical significance, one would conclude that the coefficient in math is zero and that the reading coefficient from academic minutes to achievement is only low positive. It is interesting that in the fifth year center results, the effect in

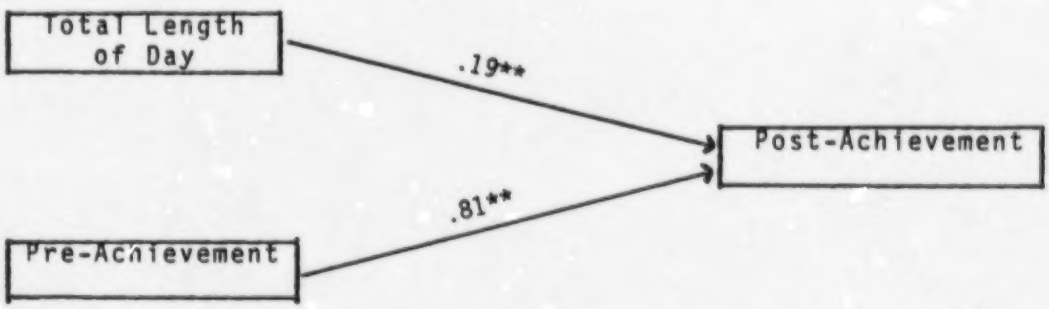
reading appears slightly greater than the math effect (contrary to all other model comparisons).

The last models to be presented are analyses of the total length of the school day as related to achievement growth. Theoretically, one would expect academic minutes per day to be the more proximal factor in its causal relation to achievement, with "total time" a more distal causal agent. However, we need to keep in mind that the "academic minutes" measure is only allocated instructional time, and it is certainly not as proximal to student performance as would be a measure of actual engaged time (which, unfortunately, is a measure not available in this study). So both of the available measures of "time-on-task" are fallible. The use of total time in the day is still a reasonable test of the "quantity of schooling" model of Wiley and Harnischfeger (1974).

Whether one considers the number of academic instructional minutes or the total length of the school day, there have to be mediating variables operating in order for the tested causal connections to yield answers indicative of support for the model. For both academic minutes and total length of day, the within-classroom instruction and actual student engagement with content are surely mediating influences. For the total length of day variable, student motivation and academic socialization might well serve as potent mediators. Recall that the total length of the day variable includes minutes for music and art, physical education, recess, lunch breaks, and other "non-academic" activities.

Time spent in these activities was not included in the "academic minutes" measure. It seems possible that schools with longer days could be fostering a stronger "bond" with the schooling process -- thereby increasing positive attitudes toward school, academic motivation, and school-related socialization. Obviously, these are only speculative comments, but it certainly seemed worthwhile to test the causal model with total length of school day as an influence on achievement.+

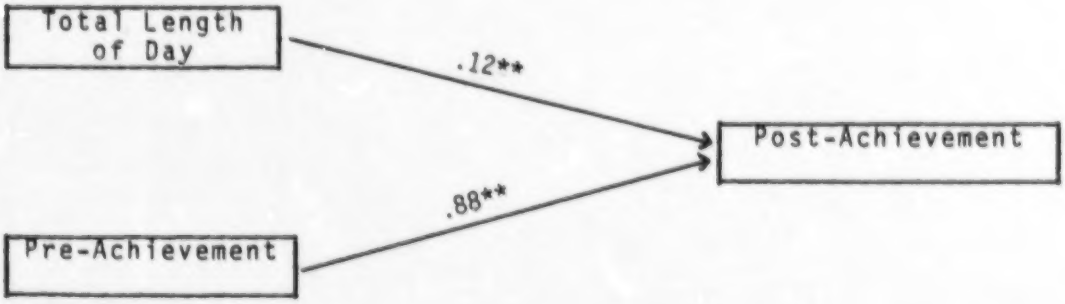
Effects of Total Length of School Day on Math, Elementary and Fifth Year Centers



** P < .05

+ We are aware that the total length of day measure is not normally distributed. The variance on that measure was determined by only a relatively few schools (12 of 67). However, there was some variance, so we proceeded with the model tests. Throughout this process, we have attempted to let theory drive the tests of models, and to avoid basing decisions about analyses on the nature of the observed data.

Effects of Total Length of School Day on
Reading, Elementary and Fifth Year Centers

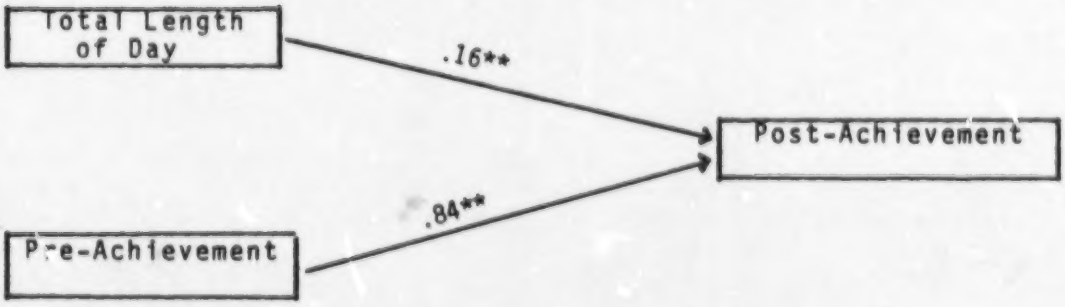


** P < .05

Somewhat surprisingly, the total length of day measure appears to be a stronger (more statistically significant) causal agent than the measure of allocated academic minutes. Consistent with earlier analyses, the effect in math is somewhat greater than the effect in reading. The schools with the longer days tend to show greater achievement growth, and those with shorter days tend to show less growth.

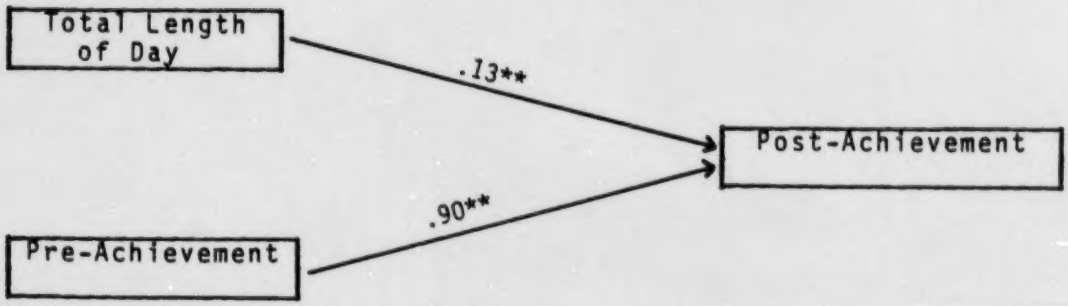
The next models assess total length of day at the elementary level only.

Effects of Total Length of School Day on
Math, Elementary Schools Only



** P < .05

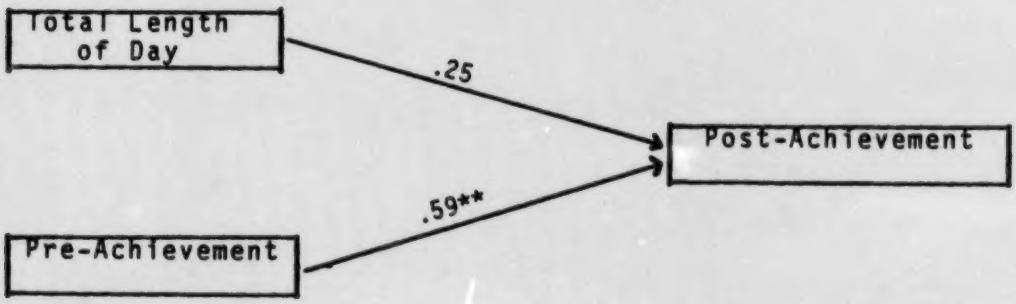
Effects of Total Length of School Day on
Reading, Elementary Schools Only



** P < .05

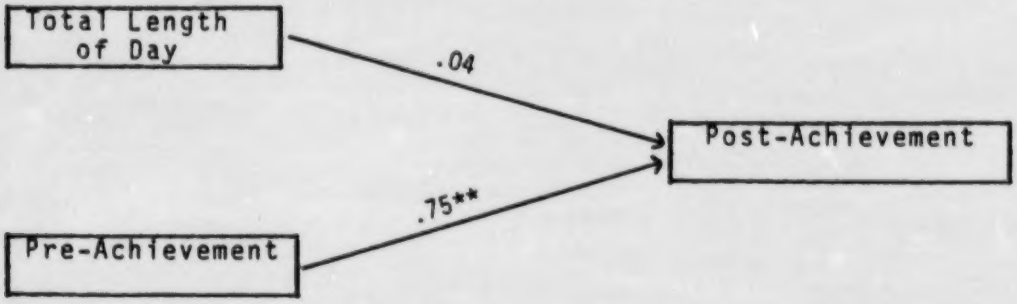
In elementary schools, the effect of total length of day is significantly positive in both reading and in math. The math effect is only slightly greater than the reading effect in elementary schools. The remaining two models test effects of length of day in fifth year centers.

Effects of Total Length of School Day on
Math, Fifth Year Centers Only



** P < .05

Effects of Total Length of School Day on Reading, Fifth Year Centers Only



** P < .05

With N of only 13, the effect of length of day on achievement growth in fifth year centers is not statistically significant. However, the coefficients are both positive in sign, and the path coefficient in math is the largest one that has resulted for an instructional variable in any of the models tested (it is not significant because the standard error is also relatively large). Even without statistical significance, one could conclude that longer days may also be beneficial in fifth year centers, particularly for math achievement growth.

Discussion

The models that tested principal effects and within-school cohesiveness among teachers were generally supported, though the effects were stronger in math than in reading. Those analyses showed more support for the model in the overall sample and for elementary and fifth year grades than in middle and high schools.

As discussed in the Crawford and Watson (1985) technical report and the Kimball et al. (1985) paper, the relevance of CAT objectives to the curriculum is relatively greater in the lower grades. We should keep in mind, too, that the models tested particular aspects of cohesiveness and principal effectiveness and not cohesiveness "in general" or principal effectiveness "in general". Within-school cohesiveness taken as most important for effects on achievement was cohesiveness of teachers with respect to academic and behavior management issues. Principal effectiveness (e.g., mean principal ratings by teachers) was considered in the context of the principal's administrative role -- regarding supplies, materials, personnel selection, etc.

The fact that school effects are stronger and more consistently significant in math than in reading is in agreement with other work that has shown the difficulty of impacting on reading achievement. For example, the nationwide Sustaining Effects Study by Carter (1980) also found greater effects in math than in reading. Carter speculated that this was caused by variation in the percentage of all instruction in reading and math that occurred in the school setting. In math, chances are that most of the instruction -- either formal or informal -- occurs in school (i.e., it may be relatively unlikely that parents will sit down with children at home and work through math exercises just for fun). In reading, the formal instruction that occurs in school may be supplemented by a considerable amount (for some students) by time spent in

reading and learning to read outside of the school setting. The fact that there will be variance in the degree to which this occurs across students may partially account for the lower estimates of school effects on reading achievement.

One of the paths in the model that was not strongly supported by the data was from pre-achievement level to within-school cohesiveness. It appears that cohesiveness may not be affected by antecedant conditions at the school (at least, not by prior school-level achievement). This could be because cohesiveness or likemindedness among teachers is affected by teacher turnover more than by prior achievement level of the school. Or, we may view this as evidence that cohesiveness is a social phenomenon that must develop during the course of the year. When it does develop, our results indicate that it may have a significant impact on achievement growth of the school (at least in the early grades in math).

The other causal models tested the effects of the quantity of schooling on achievement growth. Results showed that both the number of academic instructional minutes per day and the total length of the school day can have significant impact on achievement growth at the school-level. As in the other results, effects were usually stronger in math than in reading. We know from the work of Carroll (1963) and the recent review of time-on-task by Karweit (1983) that <u>allocated</u> time is not the same as actual <u>engaged</u> time. In this study of school-level effects, we did not have measures of engaged time. Our results replicated the work of Wiley and

Harnishfeger (1974) by showing that even crude measures of the total exposure of students to schooling can be significant determinants of learning. This finding has apparent implications for the improvement of achievement in OCPS.

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